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in transdisciplinaire
programma's

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BTO Managementsamenvatting

Conditie voor productieve interacties in transdisciplinaire programma's

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Samenwerking in transdisciplinaire programma's wordt bevorderd door een combinatie van kenmerken van de deelnemers, het programma-ontwerp en interventies door het programmamanagement, zo bleek uit drie case studies gericht op duurzame landbouw, internationaal klimaatbeleid en toekomstbestendige infrastructuur. Zicht op condities die nodig zijn voor een vruchtbare samenwerking tussen onderzoekers uit verschillende disciplines en diverse praktijkprofessionals wordt steeds dringender, nu grote uitdagingen op het gebied van milieu en klimaat vragen om een transdisciplinaire aanpak. Het BTO-WICE programma heeft de ambitie om naast waterbedrijven ook waterschappen, provincies, gemeenten of bedrijven te betrekken. Uitkomsten van het huidige onderzoek wijzen initiatiefnemers en managers van transdisciplinaire programma's op het belang van: (1) een zorgvuldige keuze van de deelnemers, (2) afstemming van de intensiteit van samenwerking op de doelen en deelnemers van het programma, (3) reservering van voldoende budget en energie voor communicatie en coördinatie, en (4) overweging van de inzet van projectmonitors: personen die de sociale leerprocessen in het programma bewaken en versterken.

	NG Infra	Clipore	TransForum
Thema	Toekomstbestendige infrastructuur	Internationaal klimaatbeleid	Duurzame landbouw
Kenmerken van deelnemers	<ul style="list-style-type: none"> Cognitieve nabijheid Persoonlijke factoren Sociale nabijheid (vertrouwen) 	<ul style="list-style-type: none"> Persoonlijke kwaliteiten Sociale nabijheid 	<ul style="list-style-type: none"> Sociale en geografische nabijheid Individueel leiderschap en commitment Gemeenschappelijk gevoel van dreiging
Programma-ontwerp	<ul style="list-style-type: none"> Verschillende sectoren met vergelijkbare problemen combineren Specifieke deelprogramma's 	<ul style="list-style-type: none"> Relatief veilig onderwerp Samenstelling van bestuur 	<ul style="list-style-type: none"> Financieringseisen voor projecten
Interventies	<ul style="list-style-type: none"> Competities en prijzen Tijdschriften 	<ul style="list-style-type: none"> <i>Policy Forum</i> Financiële flexibiliteit 	<ul style="list-style-type: none"> Projectmonitors Deelnemers uitsluiten <i>Connected Value Development</i>

Factoren en condities voor bevordering van vruchtbare samenwerking tussen uiteenlopende partijen

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Belang: transdisciplinaire samenwerking mogelijk maken voor aanpak complexe uitdagingen

De grote uitdagingen op het gebied van milieu en klimaat kunnen moeilijk worden opgelost binnen disciplinaire kaders. Ze vragen om een transdisciplinaire aanpak, waarbij onderzoekers uit verschillende disciplines samenwerken met praktijkprofessionals. Om recht te doen aan complexe uitdagingen zoals de circulaire economie moeten uiteenlopende partijen meedoen, met verschillen op het gebied van kennisniveau, belangen en relatie tot de onderzoekers. Zo is de ambitie van het BTO-WiCE programma om naast waterbedrijven ook waterschappen, provincies, gemeenten of bedrijven te betrekken. In dit rapport onderzoeken we welke condities nodig zijn zodat zij vruchtbaar kunnen samenwerken.

Aanpak: case studies van drie transdisciplinaire programma's

We hebben drie programma's geselecteerd die een complexe maatschappelijke uitdaging adresseren, namelijk TransForum (duurzame landbouw), Clipore (internationaal klimaatbeleid) en Next Generation Infrastructures (toekomstbestendige infrastructuur). Alle drie de programma's kenden een transdisciplinaire aanpak, waaraan zeer uiteenlopende partijen hebben deelgenomen. Per programma hebben we 6-7 interviews gehouden met programmamanagers, projectleiders, onderzoekers en kennisgebruikers. Daarnaast hebben we relevante documenten bestudeerd zoals evaluaties, projectplannen en jaarverslagen.

Resultaten: factoren en interventies voor bevordering van een vruchtbare samenwerking

Tegen alle verwachtingen in leverden slechts in één van de onderzochte programma's verschillen tussen kennisgebruikers problemen op. Bovendien werd in dit geval een manier gevonden om het probleem te overkomen.

De verschillende programma's lieten zien dat vruchtbare samenwerking onder meer wordt bevorderd door kenmerken van de deelnemers, zoals persoonlijke kwaliteiten en vertrouwen. Deze kunnen niet direct door programmamanagers worden beïnvloed. Twee programma's tonen aan dat ook het ontwerp van een programma kan helpen om met verschillen tussen kennisgebruikers om te gaan. In de casus NG infra draagt het

opzetten van specifieke programma's met een bilaterale samenwerking met een afzonderlijke stakeholder bij aan het vermijden van onderlinge confrontaties. De casus Clipore illustreert hoe de keuze voor een relatief veilig onderzoeksonderwerp kan helpen in het beperken van spanningen tussen kennisgebruikers.

Door middel van maatwerk stimuleren de programma's productieve interacties. De interventies variëren van competities tot praktijkgerichte bijeenkomsten en de inzet van projectmonitors. TransForum maakte gebruik van de meest onderscheidende en vernieuwende interventie: de aanstelling van projectmonitors, verantwoordelijk voor het volgen en versterken van sociale leerprocessen. Hun inbreng en feedback werd uiteindelijk breed gewaardeerd, ook al waren zij aanvankelijk met enige argwaan benaderd.

Implementatie: vier aanbevelingen voor initiatiefnemers en managers

Op basis van deze analyse doen we vier aanbevelingen voor initiatiefnemers en managers van transdisciplinaire programma's, zoals BTO-WiCE:

1. Kies je programmadeelnemers zorgvuldig: voldoende vertrouwen en inhoudelijke aansluiting helpt om organisatorische verschillen en normatieve conflicten te overbruggen.
2. Ontwerp je programma op maat, gegeven je doelen en deelnemers: afhankelijk van de variatie in normatieve posities en verwachtingen in het programma zal intensievere of extensievere samenwerking mogelijk of noodzakelijk zijn.
3. Besteed niet al het geld aan onderzoek: reserveer budget en energie voor communicatie en coördinatie.
4. Overweeg de aanstelling van projectmonitors wanneer je programma is gericht op het faciliteren van de samenwerking tussen kennisgebruikers met conflicterende perspectieven.

Rapport

Dit onderzoek is beschreven in het rapport *Samenwerken met uiteenlopende partijen (BTO 2017.088)*.

Summary

There is wide agreement about the importance of transdisciplinary research to address complex environmental issues. Although there is a growing body of literature about the management of transdisciplinary research programmes, empirical research has to date paid little attention to the challenges related to the variation of knowledge users involved in these programmes. This paper presents a comparative analysis of three transdisciplinary programmes addressing climate change and sustainability, and identifies factors and conditions that contribute to productive interactions between heterogeneous actors. Contrary to what could be expected from the literature, differences between the knowledge users involved have only created significant issues in one of the programmes, and this programme has developed a way to limit this problem. Effective strategies to avoid and limit tensions among knowledge users include a focus on bilateral collaborations, the careful selection of programme participants and the appointment of dedicated project monitors, responsible for social learning processes.

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1 Introduction

Transdisciplinary research is generally perceived as a promising mode to tackle complex environmental challenges (de Jong et al. 2016; Hadorn et al. 2008; Lawrence 2015). In its ideal type, transdisciplinary (TD) research is characterised by a longer-term collaboration between academic researchers from different disciplines and knowledge users (from different sectors). TD research integrates knowledge and skills from these different backgrounds, aiming to solve a common practical problem (Rosenfield 1992). Indeed, the involvement of knowledge users has been found to result in knowledge that is more relevant to, and useful in, practice (Jolibert and Wesselink 2012; Walter et al. 2007). Knowledge users help to adapt knowledge to local contexts and to translate scientific terminology to concepts that are understood in practice (O'Fallon and Deary 2002; Weichselgartner and Kasperson 2010).

Given that the goals, incentive structures and freedom of operation differ strongly between academic researchers and knowledge users, the organisation of TD research requires additional efforts compared to more traditional research modes. Collaboration between actors with different backgrounds is a challenge in itself, accompanied with a number of potential barriers, including cognitive, organisational, social and institutional differences (Boschma 2005). While scientific reward structures are still largely based on publications, knowledge users are incentivised to contribute to profit or policy-making, so they have to balance long-term strategic goals with short-term relevance (Boon et al. 2014; Kloet et al. 2013). There is a growing literature on TD research, dealing with experiences and best practices for collaborating between academic researchers and knowledge users in TD research projects (Boon et al. 2014; Hegger et al. 2012; Klenk and Meehan 2017), and the organisation of TD research programmes (de Jong et al. 2016; Hessels et al. 2014). However, so far the collaboration between knowledge users within TD research and the effects of this collaboration on the outcomes of TD research is underrepresented in literature. With this paper we aim to address this gap by analysing three TD research programmes directed at societal challenges related to climate change and sustainability. Our research question is what factors or conditions have contributed to productive interactions between heterogeneous knowledge users in the production of knowledge for complex societal challenges.

In the next section we introduce our theoretical framework. The method is discussed in section 3, including an introduction of the three TD research programmes. Section 4 describes the variety of knowledge users that were involved in the three programmes under study. In section 5 we provide a comparative analysis of the different programmes and identify the factors that have promoted productive interactions. In section 6 we answer the research question, relate our findings to existing literature and present recommendations for the management of TD programmes.

2 Theoretical framework

Evaluations and analysis of TD projects show that interactions and understanding between the different actors involved are crucial for successful knowledge production. Success conditions reported for joint knowledge production include a shared understanding on goals and problem definitions and organised reflection on division of tasks (Hegger et al. 2012). Also project size, team composition and division of responsibilities within teams have been shown to influence the success of TD projects (Boon et al. 2014). Moreover the skills and capacity of TD researchers to pay attention to the friction and tensions provoked by TD collaboration and to reveal what is relevant to their knowledge users have been found valuable for fruitful interactions (Klenk and Meehan 2017).

A possible barrier for collaboration is that university scientists often have difficulties in recognising the relevance of experiential knowledge (Benard and de Cock-Buning 2014) and in striking a balance between actively involving professionals/practitioners and protecting the independence and quality of the research (Van Buuren and Edelenbos 2004). These issues seem less pertinent in the case of applied research organisations (Brouwer et al. 2018). Conflicts can also emerge due to different priorities of research partners and practitioners (Kloet et al. 2013).

Although previous research on TD has addressed the variety of actors or organisations that can participate in TD research, there has been little empirical attention to the ways how TD programmes can deal with the variety of knowledge users involved within a particular programme. Given the wide range of possible stakeholders (Mitchell et al. 1997), the knowledge users involved in a given programme can vary strongly in terms of their knowledge level, power or normative position in relation to the research topic. These differences can create strong inequalities and tensions between them. Different preferences make it difficult to reach agreement about the relative emphasis on basic versus applied research projects in the research agenda (Kloet et al. 2013) or between monodisciplinary versus interdisciplinary research priorities (Brouwer et al. 2018). Different knowledge users can also have different expectations of the project outcomes, for example the degree of uncertainty (Boon et al. 2014) and hold different perspectives on co-production, which can create conflicts about their precise role and responsibilities in the research process (van der Hel 2016).

Knowledge users – a term in this paper used as a synonym for all stakeholders that participate in a particular research programme - can play a range of different roles in TD programmes varying from influencing the research agenda to actively participating in data collection or assisting in the interpretation of findings and the translation of research results to practical contexts (Hadorn et al. 2008; Lawrence 2015). Their role can change dramatically over the course of a project or programme, as a result of engagement with the research and encounters with the researchers (Klenk and Meehan 2017). Following Hessels et al. (2014), we distinguish between involvement of knowledge users on the programme level, the theme level and the project level. On the programme level, knowledge users typically participate in decision making about the overall goals, programme design and the research priorities of the programme (Hessels et al. 2014; Wardenaar et al. 2014). On intermediate level of research themes, clusters or sub-programmes, knowledge users can be given a responsibility to oversee a particular set of research projects, to supervise the progress and

relevance in a particular research theme or to establish links between ongoing research activities and topical political, economic or social developments (de Jong et al. 2016). On the project level, there are many different manifestations of TD, in which practitioners or knowledge users participate to a varying extent (Mobjörk 2010).

In this paper we use the concept of productive interactions to refer to fruitful collaboration between the various participants of TD programmes. This concept was introduced as a process indicator of social impact of research, to overcome the problems of measuring the eventual impacts. Spaapen and van Drooge have defined productive interactions as exchanges between researchers and knowledge users in which knowledge is produced and valued that is both scientifically robust and socially relevant (Spaapen and van Drooge 2011). These exchanges can be mediated through various objects such as a publication, an exhibition or a design. The interaction is considered productive when it leads to efforts by knowledge users to use or apply research results, practical information or experiences. Since productive interactions can be seen as a crucial condition for impact, they can also be used as a process indicator of social impact (de Jong et al. 2011; Spaapen and van Drooge 2011). In this paper we extend the notion of productive interaction to include exchanges between different knowledge users as well. Because of the active participation of knowledge users in TD programmes, the distinction between knowledge producers and knowledge users is blurry. In this context the interactions between these knowledge users can also add value to the knowledge produced in the programmes.

3 Methods

In order to address our research question, we have conducted case studies of three transdisciplinary programmes. All programmes focused on a complex societal challenge, one focusing on international climate policies, one on future-proof infrastructures and one on sustainable agriculture (see table 1). They all integrated different disciplinary perspectives and included knowledge coproduction by researchers and knowledge users. In all cases the knowledge users involved showed a variation in terms of their type of organisation (government, industry, NGO), size of organisation (fte), and/or knowledge level. The programmes all had an annual budget in the range of 1-10 Million euros and were finished at the time of research (but not longer than 10 years).

TABLE 1. OVERVIEW OF THE CASES

	Next Generation Infrastructures	Clipore	TransForum
Mission	To understand how infrastructures work and to develop practical solutions that will steer infrastructural developments	Support far-reaching and cost-effective international climate policy developments through policy-oriented research and targeted science-based dialogues with policymakers and stakeholders	An inspiring vision on the future of Dutch agriculture, a structured approach to realise this vision, and the embedment of this vision and approach in agricultural practice
Main disciplines	Civil engineering, public administration	Economics, environmental science, political science and law	Agricultural engineering, environmental science, innovation studies
Main knowledge users involved	Utilities, public authorities, consultancies, SMEs	Industry, national governments, multinational authorities, advocacy groups (NGOs)	Farmers, food industry, government, NGOs
Duration	2004-2015	2004-2010	2005-2010
Funding amount and source	19 M euros from BSIK fund and 21 M euros matching from programme partners	108 M Swedish Kroner (about 11 Million euros) from Mistra Foundation	30 M euros from BSIK fund and 30 M euros matching from programme partners
Location	The Netherlands	Sweden, USA, India	The Netherlands
Number of projects	145	31	>100 (33 innovation projects)
Number of interviews	8	7	7

For each case we have interviewed 7-8 individuals with programme directors, project leaders, researchers and representatives of knowledge users. In the semi-structured interviews we asked questions about their own role in the programme, the characteristics, positions and interests of different knowledge users, and the dynamics of collaboration among the various actors involved. We also studied relevant documents about the programmes, including annual reports, evaluation reports, project proposals and academic papers reflecting on the programmes studied.

4 Variation between knowledge users in practice

4.1 NG Infra

NG Infra involved knowledge users responsible for or active in physical infrastructures. Represented sectors include railway, utilities, roads and water. Involved users include public bodies, such as the Ministry of Infrastructure and the Environment and the Directorate-General for Public Works and Water Management ('Rijkswaterstaat')¹, semi-privatised firms, including Dutch Railways, and private companies from the utilities sector. Furthermore, the organisations involved vary from relatively small companies with around 20 employees to very large organisations with thousands of employees. Similarities include the types of challenges they face and a cautious attitude, because of their position under public scrutiny. The majority of them are geographical monopolists responsible for or providing a specific and often critical infrastructure. As a result, their functioning and processes are closely followed by politics, the media and the public. On the project level, representatives from large and small organisations collaborated on concrete problems. However, the involvement of multiple knowledge users in a single project seems to be rare: only 20% of the 145 projects involved more than one.

4.2 Clipore

The knowledge users of the Clipore programme are actors involved in the design of carbon emission trading systems and the actors involved in the international negotiations about their implementation, in particular: industry, national governments, state governments (USA), and NGOs (advocacy groups).

In spite of the general controversies about climate policies, the knowledge users structurally involved in the Clipore programme did not vary strongly in their opinions or stakes with regard to the topic. The programme focused on effective instruments in emission trading rather than the need for emission trading as such. Only actors were involved in the programme that were in favour of climate policies in the first place. The fossil fuel industry and advocacy groups, which have the strongest opinions about climate change and climate policies, were not structurally involved. The knowledge users of Clipore on the project level varied strongly in terms of their knowledge level with regard to the topic. The programme's seminars and contributions to 'side events' have been appreciated most strongly by governments from low-income countries, who had the least knowledge about the topic.

4.3 TransForum

The knowledge users of the TransForum programme are civil society organisations (including consumer organisations), governmental bodies, and industry (including farmers) that have a stake in the transition towards a more sustainable development of the Dutch agricultural sector (Veldkamp et al., 2008). The programme's Advisory Board was (in the second stage of the programme) composed of representatives from multiple interest groups and the scientific community. The active involvement of and collaboration between

¹ the government agency responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands

governmental bodies, civil society organisations, the business community and knowledge institutes was – except for the very start - prerequisite for the programme funding of all innovation projects in the Practice Programme. In the two other parts of the programme, the Scientific and Learning Programme, knowledge users were mostly only indirectly involved, for instance, by formulating research questions or sharing best-practises.

In TransForum there was a large variation in terms of knowledge level, goals, and (organisation) power among knowledge users. Most prominent was the variation in the normative position of the different knowledge users with regard to the research topic. So in terms of the three well-known sustainability p's people, planet and profit, the agricultural entrepreneurs focus primarily was on profit, whereas environmental NGO's instead first and foremost focus on planet. As a result, the programme generated considerable debate among knowledge users regarding, for instance, the issue what is sustainable and what not. Instead of avoiding these kind of value conflicts, a distinctive feature of the programme was that it intentionally embraced this variation. One of the key assumptions of the programme is that a system innovation requires a multi-stakeholder approach exactly for the reason that, in this instance, farmers, citizens, researches and governments all have different values concerning environmental, social and economic aspects of agricultural production (van Latesteijn and Andeweg 2010).

5 Conditions for productive interactions

5.1 The role of knowledge users

The ways in which knowledge users were involved vary strongly across the three cases. In all programmes knowledge users were involved in the agenda-setting phase; in TransForum they were also strongly involved in the execution of projects and the implementation of the outcomes. Here the collaboration in the innovation projects in the Practice Programme sometimes entailed almost daily interactions. In the other programmes knowledge users participated in various meetings and events. In NG Infra also some researchers hold office at the knowledge users office for part of their time.

In all programmes researches have engaged with knowledge users on the programme level by direct representation in the programme board or participation in a programme-wide user committee or advisory committee. At NG Infra, major infrastructure providers such as railroad infrastructure manager ProRail, were involved in designing the programme and represented in the programme's user council. In Clipore, industry and government met as members of the programme board, and at a number of meetings and workshops, such as the European Climate Platform. In TransForum knowledge users participated in the Advisory Board.

On the project level there was intensive involvement in TransForum, formal but less intensive involvement in NG Infra, and only incidental involvement in Clipore. In TransForum, the interaction between knowledge users and knowledge producers was most manifest on the project level. Especially agricultural entrepreneurs and knowledge institutes were present at all project stages from agenda-setting to implementation. Furthermore, various interviewees expressed some disappointment with the actual role of some of the involved governmental bodies, which was perceived as somewhat distant and evaluative rather than reflexive, despite their important funding role.

The NG Infra programme management allowed project leaders to shape the involvement of knowledge users as they saw fit. Just over 50% of projects formally involved knowledge users: 47 projects involved one knowledge user and 28 projects involved two or more knowledge users. On this level, knowledge users could closely collaborate with academic researchers. This includes jointly establishing research agenda's and submitting proposals, designing and conducting research and disseminating, including co-authoring academic papers, and implementing results. Knowledge users made financial and in-kind contributions. The intensity ranged from periodical meetings to academics working on the premises of knowledge users for a prolonged time.

In Clipore knowledge users were not structurally involved on the level of WPs or projects and most of the projects were relatively academic in nature, but one project leader (C3) indicates that knowledge users indirectly had a strong influence on the agenda of the WP about the design and implementation of emission trading. In many projects, knowledge users have given feedback to (preliminary) findings during side-events, workshops or other meetings. In

one case the UNFCCC secretariat contributed to the data collection by giving permission to circulate a survey among the participants of the Conference of the Parties².

5.2 Productive interactions

In all cases the mutual relationships among knowledge users involved in the programmes have been characterised as good by our interviewees. The NG Infra programme management involved users through large annual events such as NG Infra Trends, summer school NG Infra Academy, websites, information booklets and a magazine to facilitate learning among knowledge users and projects, to wider disseminate results and to create a network among and between knowledge users and academic researchers. In the case of Clipore the interaction with fossil fuel industry has been complicated but these interactions were not part of the programme, as the programme has deliberately chosen to collaborate with actors with more common ground. In TransForum the relationships were generally perceived as productive, but given the large variation and different values and accompanying visions of a sustainable agriculture, never obvious or easy. Acknowledging and making an effort to understand each other's differences were therefore considered very important. In some TransForum projects interactions with external stakeholders have been complicated, that is some environmental NGOs that were not part of the programme.

In spite of the varying intensity with which knowledge users were involved, they have contributed to the relevance and impact of all three programmes. At NG Infra, the interactions with knowledge users have helped to improve the relevance of the research capacity and to develop a cross-sectoral network. This network has continued to exist after the programme ended. Six knowledge users have initiated a follow-up programme and there are also follow-up projects outside this programme with funding from other schemes. In the Clipore programme, the board has helped to design mechanisms for disseminating the knowledge both to negotiators and to a broader audience. The (limited) interactions that have taken place between researchers and knowledge users on the project level have contributed to the relevance of the programme, to the implementation of some research findings in the design of emission trading systems in Europe and USA, and to the generation of sustainable knowledge networks. In TransForum, all interviewees recognise the significance and value of the multi-stakeholder approach that was chosen in the programme. The involvement of a combination of actors, and in particular entrepreneurs on project level, was crucial for developing new conceptualisations of sustainable agriculture, building enduring networks, and implementing a number of successful innovations. By accepting the different values of the different knowledge users, room was created for new solutions and ideas. An appealing example in this respect is the innovation project Rondeel in which entrepreneurs, research institutes, and societal organisations jointly developed a sustainable housing system for chicken, with less environmental impact, an improved animal health and welfare, as well as business efficiency. Today, Rondeel eggs are on the shelves of all major Dutch supermarkets (Fischer et al. 2012).

5.3 Barriers for collaboration

Altogether, differences between users have hindered collaboration only to a limited extent. Surprisingly, the power and knowledge differences that existed in all three cases have hardly hindered mutual collaboration.

Differences in value orientation and interests seem the most hindering. These differences were present in TransForum, initially resulting in semantic discussions on the board level on

² the supreme decision-making body of the UN Framework Convention on Climate Change.

the concept of sustainability, and to a lesser degree in some of the innovation projects. For instance, in the project Streamlining Greenport Venlo, which aimed at strengthening and (re) organising the horticulture chain and societal co-operation structure in the region, differences became manifest in the search for environmental NGOs to join as they often didn't agree with the project's goal of stimulating the economy. In the TransForum project New Mixed Farm, aiming to combine different businesses by making use of each other's waste and residual streams, the differences in value orientation and interests became most manifest outside the project (Hoes and Regeer 2015). Although some - what interviewees refer to as - 'constructive' environmental NGOs were part of a special advisory board, more radical environmental NGOs were heavily opposed, and created a massive social resistance, which in turn, had negative effects on the internal support and cooperation between the project partners.

NG Infra has avoided possible tensions between knowledge users by organising bilateral relationships and by carefully selecting motivated knowledge users. On the programme level NG Infra the interactions were mainly bilateral, by setting up specific sub programmes for the most prominent knowledge users. On the project level such situations seem to have been avoided by 1) organising most projects as bilateral projects involving only a single stakeholder or 2) carefully selecting stakeholders to make sure they were capable and motivated to collaborate.

In Clipore differences among knowledge users do not seem to have significantly hindered the cooperation, because the knowledge users that have most actively contributed to the programme 1) were only involved to a limited extent and 2) did not vary strongly in terms of knowledge level or interests. The knowledge level varied most significantly among actors engaging on project level, yet did not hinder the interactions. Also the value orientation did not differ strongly between the board members or between the main users on the project level. All were in favour of climate policies, and were interested in effective policy instruments. The users on the project level differed more, and the organisations also changed opinions or priorities rapidly, which complicates the cooperation. But also on project level, the knowledge users we have interviewed have not experienced that differences complicated the cooperation: 'I don't think the differences among stakeholders complicated things. I believe that diversity of opinions always makes stronger research.' (interview C4)

5.4 Explaining productive interactions

The productive interactions within these three programmes can be explained by a combination of (1) characteristics of the programme participants, (2) design of the programme, and (3) interventions by the programme management (see table 2).

In terms of **participant characteristics**, personal leadership, social proximity (trust, good atmosphere) and cognitive proximity have promoted the collaboration in the various programmes. According to the various interviewees the success of projects was related to the commitment and leadership of individual actors willing to go for that extra mile, such as a committed alderman or an avid project leader. In Clipore the programme director and the chairman of the board together made sure that the board meetings were attractive to attend. All board meetings were started by giving everyone the opportunity to talk for a couple of minutes with particular news or concerns or research results. Interactions in NG Infra also seem to have benefitted from social and cognitive proximity. In successful projects we found academics that were interested in the daily operating of companies or were trained in understanding the knowledge user by holding office at the knowledge user's premises, and knowledge users with experience in academic research or with an intrinsic interest in the

research matter. In TransForum the different knowledge users shared an indefinable feeling that the practice of Dutch agriculture at some point had to change. Combined with the idea that this transformation couldn't be established by knowledge users alone, this shared conviction enabled and facilitated the collaboration.

When looking at the **programme design**, choosing a strategic focus for the programme has been an influential factor. The initiators of both NG Infra and Clipore have chosen a relatively safe approach within an area full of controversies. In NG Infra the recognition of each other's problems (both practical in terms of managing infrastructures as well as in being closely monitored by government, politics and the general public) brought knowledge users together and created willingness to exchange experiences and to jointly work on solving these problems. The different sectoral backgrounds introduced an element of safety. Experiences could be exchanged without competitors being around. The choice of the Clipore board not to focus on the question how stringent emission policies should be, but to look into effective mechanisms and instruments helped to create a neutral identity towards all knowledge users, without threatening any actors. A crucial aspect of the TransForum programme design was the rule that all projects in the Practice Programme required the involvement of and collaboration between governmental bodies, civil society organisations, the business community and knowledge institutes, in order to qualify for funding.

The three programmes have used a wide range of **interventions** to promote productive interactions.

Participants of TransForum have been careful in the inclusion and exclusion of actors. Various interviewees stated that they were keen on inviting (or not inviting) specific individuals within organisations in (particular stages of) the process: 'some individuals were excluded as they lacked the willingness to innovate or the courage of choosing a new manner of collaboration' (T3). Second, all TransForum practice projects were supported by an institutionalised monitoring mechanism, part of the learning programme. After some successful pilots, a so-called project monitor was assigned to each practice project aiming to improve and speed up social learning by offering reflections on on-going events and by facilitating reflection meetings (Peterson and Mager 2010). Initially the involvement of a project monitor was optional, later it was conditional to qualify for funding. Third, TransForum applied a so-called Connected Value Development approach, aimed at transforming perceived trade-offs into complements, by connecting the values held by the different knowledge users. This approach encompasses the explicit recognition of differences between knowledge users, in terms of problem definitions, proposed solutions, interests and values. The project monitors helped to identify existing differences and treat them as an asset rather than smooth them over or deny them. Another element of TransForum, exemplifying that the programme aimed at the practical application of the organisation theory by Peter Senge (Senge 2014), was the formation of the guiding idea metropolitan agriculture, that mobilised the different knowledge users (Peterson and Mager 2010).

At NG Infra the introduction of prizes and competitions seem to have stimulated collaboration among programme participants. Moreover, NG Infra Trends and NG Infra Magazine (under different names) organised by the programme, provided a stage to interact with stakeholders that were not directly involved in the project. Smaller events organised on the project level served the same purpose. Projects also used communication and coordination instruments of the university involved such as prizes, alumni events and Youtube channels.

In the Clipore programme, two interventions can be distinguished that have promoted productive interactions. First, dedicated funds for the 'Clipore Policy Forum' (later renamed European Climate Platform), a series of events organised together with the Centre for European Policy Studies (CEPS). These events, and the contributions to formal side events of COPs seemed to have been crucial for interacting with key knowledge users³. The second intervention is to organise financial flexibility: the programme has gradually learned to find a good balance between accountability and flexibility in the research agenda. 'In the first phase we had all WPs and authors told specifically what to do. Towards the end we found out that we had to be more flexible to questions from knowledge users.' (C3)

TABLE 2. FACTORS PROMOTING PRODUCTIVE INTERACTIONS

	NG Infra	Clipore	TransForum
Participant characteristics	Cognitive and social proximity	Personal qualities	Social and geographical proximity
	Personal factors	Social proximity	Individual leadership and commitment
Programme design	Combining different sectors with similar problems	Focusing on a relatively safe topic	Shared feeling of threat
	Dedicated sub-programmes	Board composition	Programme funding prerequisites
Interventions	Competitions and prizes	Policy Forum	Project monitors
	Periodicals	Financial flexibility	Exclusion of actors
			Connected Value Development

³ Christian Grorud, 2006, Mistra's Climate Policy Research Program - Phase II; Evaluation of value to users

6 Conclusions and discussion

This paper addresses the question what factors or conditions contribute to productive interactions between heterogeneous actors in the production of knowledge for complex societal challenges. We have analysed three transdisciplinary research programmes, and compared the way they have dealt with variation among the knowledge users involved. In all three programmes, the involvement of heterogeneous actors was considered an added value. Contrary to what could be expected from the literature (Boon et al. 2014; Kloet et al. 2013; van der Hel 2016), it turns out that the differences between knowledge users have only created significant issues in one of the programmes, and also this programme has developed a way to overcome this problem.

Some factors that contribute to productive interactions are characteristics of the participants, which cannot be immediately influenced by the programme management. In this category we found similarities between the cases, in particular personal qualities and trust. This finding resonates with the proximity literature which suggests that social proximity can help to overcome organisational and cognitive distance (Boschma 2005) and with previous studies that identified personal competences and leadership as key factors for successful TD research (Brouwer et al. 2018; Goven et al. 2015).

Two of the cases illustrate that the programme design can also help to deal with variation between knowledge users. The case of NG Infra shows that setting up specific programmes for the most prominent knowledge users to work bilaterally with the research organisations can limit the confrontations among different knowledge users. Bilaterally organised projects may also reflect a balance between the demand of the programme to involve knowledge users and the academic preference to limit the involvement of knowledge users due to academic quality standards (Felt et al. 2012; Hessels et al. 2011). The outcome is involving a single knowledge user to meet funding demands, simultaneously ruling out potential hampering effects of differences between knowledge users. In the case of multi-partner projects, the programme seems to have followed the strategy to carefully select those knowledge users that will bring energy instead of trouble. The case of Clipore illustrates how the choice of the programme's topic or mission can help to reduce tensions between knowledge users. By formulating a rather instrumental and modest mission, the programme has managed to create a fruitful atmosphere for collaboration in a policy domain that is full of tension and controversies.

The interventions to promote productive interactions vary strongly across the programmes, ranging from competitions to practice-oriented meetings and the appointment of project monitors. Apparently, each programme has chosen tailor-made interventions. The most distinctive and innovative intervention we have found is the appointment of project monitors, responsible for improving social learning processes in TransForum. Although initially often looked upon with suspicion (*'I can do without someone looking over my shoulder'* T2) by regular project managers, in a later stage the feedback/added value of these monitors, who were not involved in day-to-day network orchestration but acted from a more distanced position, was generally recognised. This finding is in line with earlier studies that indicated the value of organised reflection and dedicated facilitators for transdisciplinary collaboration (Benard and de Cock-Buning 2014; Merx 2012).

Based on our analysis, we have four recommendations for initiators and managers of TD programmes:

1. Choose your programme participants carefully: sufficient social and cognitive proximity among your participants can help to overcome organisational distance and normative conflicts
2. Tailor the design of your programme to its specific goals and its participants: depending on the variety in normative positions and expectations of programme participants, more intensive or extensive collaboration will be possible and necessary
3. Do not immediately spend all money on research: reserve funding for communication and coordination instruments, and maintain a form of financial flexibility in the research agenda
4. Consider the appointment of project monitors if the programme aims to facilitate collaboration among knowledge users with conflicting perspectives

While these recommendations can help to limit conflicts within TD programmes, a certain degree of tension among participants may be part of the game (Klenk and Meehan 2017); ruling out all potential disagreements could harm the innovative potential of the TD approach. The three programmes we studied have all gone through a learning process about how to deal with their different knowledge users. They have dealt with this issue to some extent in their programme design, but have also adapted their strategies along the way. Few of the interventions by the programme management to deal with the variation have been chosen or implemented at the start of the programmes. Most have been invented in reaction to the way the programmes proceeded over time. We hope that our analysis and recommendations help TD programmes and policy makers to support productive interactions among various actors and in this way contribute to the solution of environmental challenges.

7 References

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